

FORMS PTO-1390
(REV 10-95)

U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

ATTORNEY'S DOCKET NUMBER

**TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371**

SI01-011

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

10/031917

INTERNATIONAL APPLICATION NO.

PCT/DE00/02397

INTERNATIONAL FILING DATE

July 21, 2000

PRIORITY DATE CLAIMED

July 21, 1999

TITLE OF INVENTION

OPTICAL COUPLING DEVICE

APPLICANT(S) FOR DO/EO/US

Corning Incorporated

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This express request to being national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
 - a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☒ has been transmitted by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
 - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☒ have been transmitted by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☐ have not been made and will not be made.
8. ☒ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. To 16. Below concern document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An Assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A **FIRST** preliminary amendment.
14. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:
 - Original Translation of PCT Application
 - Version of Application With Markings to Show Changes Made
 - CLEAN** Version of Amended Application, to be used for examination purposes

U.S. APPLICATION NO. (If known, see 37 CFR 1.5)

10/031917

INTERNATIONAL APPLICATION NO.

PCT/DE00/02397

ATTORNEY'S DOCKET NUMBER

SI01-011

17. ☒ The following fees are submitted:

BASIC NATIONAL FEE (37 CFR 1.492 (a)(1)-(5):

Neither international preliminary examination fee (37 DFR 1.482)
nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO
and International Search Report not prepared by the EPO or JPO.....\$1040.00
International preliminary examination fee (37 CFR 1.482) not paid to
USPTO but International Search Report prepared by the EPO or JPO.....\$890.00
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but
international search fee (37 CFR 1.445(a)(2)) paid to USPTO.....\$740.00
International preliminary examination fee paid to USPTO (37 CFR 1.482)
but all claims did not satisfy provisions of PCT Article 33 (1)-(4)\$710.00
International preliminary examination fee paid to USPTO (37 CFR 1.482)
and all claims satisfied provisions of PCT Article 33(1)-(4).....\$100.00

CALCULATIONS

ENTER APPROPRIATE BASIC FEE AMOUNT = \$890.00

Surcharge of \$130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from
the earliest claimed priority date (37 CFR 1.492(e)).

\$

CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	
Total claims	10 - 20 =	0	X \$18.00	\$.00
Independent claims	2 - 3 =	0	X \$84.00	\$.00
MULTIPLE DEPENDANT CLAIM(S) (if applicable)			+ \$270.00	\$

TOTAL OF ABOVE CALCULATIONS = \$890.00

Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity
Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28)

\$

SUBTOTAL = \$890.00

Processing fee of \$130.00 for furnishing the English translation later than ☐
20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)).

\$

TOTAL NATIONAL FEE = \$890.00

Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment
must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31).
\$40.00 per property +

\$

TOTAL FEES ENCLOSED = \$.00

I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office
to Addressee" service under 37 CFR 1.10 on the date indicated below and is Addressed to the Commissioner of Patents
and Trademarks, Washington, DC 20231

on 1/19/02 By: Bethany Beligoth
(Date) Signature: Bethany Beligoth

"EXPRESS MAIL" Mailing Label No. EV041470318 US

- a. ☐ A check in the amount of \$ _____ to cover the above fees is enclosed.
- b. ☒ Corning Incorporated hereby authorizes use of **Deposit Account No. 03-3325** in the amount of
\$ 890.00 to cover the above fees. A duplicate copy of this sheet is enclosed.
- c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any
overpayment to Deposit Account No. 03-3325. A duplicate copy of this sheet is enclosed.

**NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR
1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

Send all correspondence to:

Walter M. Douglas
Corning Incorporated
SP-TI-03
Corning, NY 14831

Signature Walter M Douglas

Registration No.: 34,510
(607) 974-2431

**Amount to be
refunded:
Charged: \$890.00**

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor: Gerhard Heise et al.

Serial No: TBA

Filing Date: Herewith

Title: OPTICAL COUPLING DEVICE

Art Group Unit: TBA

Examiner: TBA

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, DC 20231

PRELIMINARY AMENDMENT

Prior to examination of the above captioned application and issuing an office action on the merits, please enter this amendment, as set forth below.

IN THE SPECIFICATION

Please see attached application entitled "Clean Version of Amended Application".

IN THE CLAIMS

Please see attached application entitled "Clean Version of Amended Application".

REMARKS

This application is a national stage filing under 35 U.S.C. § 371 of PCT Application No. PCT/DE00/02397, filed July 21, 2000, which was filed in the German language. Enclosed herewith please find a copy of the application translated into English as received from the translating party, entitled "Original Translation". Also enclosed please find a copy of the application as amended with additions underlined and deletions in brackets, which application is entitled "Version of Application with Markings to Show Changes Made". Finally, enclosed please find a clean copy of the application as amended, entitled "Clean Copy of Amended Application". Applicants enclose copies of the complete application to show the changes made and a clean copy of the complete application because under the new rules, we would have had to replace almost every paragraph in the application in this Preliminary Amendment. Applicants believe that no new subject matter has been added to the application.

Applicants respectfully that all amendments made herein be duly entered into the application. If there are any question, please contact applicants' undersigned attorney.

Conclusion

Based upon the above amendments and remarks, Applicants believe the pending claims of the above-captioned application are in allowable form and patentable. Applicants respectfully request consideration of the application as amended and a prompt Notice of Allowance thereon.

Applicants believe that no extension of time is necessary to file this Preliminary Amendment. Should Applicants be mistaken, Applicants respectfully request that the Office grant such time extension pursuant to 37 C.F.R. § 1.136(a) as necessary to make this amendment timely, and hereby authorizes the Office to charge any necessary fee or surcharge with respect to said time extension to the deposit account of the undersigned firm of attorneys, Deposit Account 03-3325.

Please direct any questions or comments to Walter M. Douglas at (607) 974-2431.

Respectfully submitted,

CORNING INCORPORATED

Date: Jan 18, 2002

Date of Deposit: 1/19/02

I hereby certify that this paper (along with any paper referred to as being attached or enclosed) is being deposited with the United States Postal Service on the date indicated above with sufficient postage as first class mail in an envelope addressed to the: Commissioner of Patents and Trademarks, Washington, DC 20231

Signature Bethany Belizet

Walter M. Douglas
Walter M. Douglas

Registration No. 34,510

Corning Incorporated

Patent Department

Mail Stop SP-TI-03-1

Corning, NY 14831

2002 JAN 18 11 19 AM '02

VERSION OF APPLICATION WITH MARKINGS TO SHOW CHANGES MADE

SI01-011

OPTICAL COUPLING DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of priority under 35 U.S.C. § 119 of German Patent Application No. 19934178.8, filed July 21, 1999, and is a national stage filing under 35 U.S.C. § 371 of PCT Application No. PCT/DE00/02397, filed July 21, 2000.

FIELD OF THE INVENTION

[0001] The invention relates to an optical coupling device for cross-coupling light from a first optical waveguide into a second optical waveguide. Such a coupling device is known, for example, from WO 98/13718.

BACKGROUND OF THE INVENTION

[0002] [Such coupling] Coupling devices are used in optical filters according to the phased-array principle with an injection face in which light enters at a specific geometrical position, the geometrical position influencing the output wavelength of the optical filter. Such optical filters according to the phased-array principle are used, in particular, as multiplexers or demultiplexers in optical wavelength multiplex operation (WDM), since they exhibit low insertion attenuation and high cross-talk suppression. The optical filter has, as its essential component, a plurality of curved optical waveguides of different length, which form a phase-shifter region. German Patent Application DE 44 22 651.9 describes that the central wavelength of a phased-array filter can be established through the position of an injection optical waveguide, which guides the light into the layered optical waveguide. In this way, the central wavelength of the optical filter can be adjusted accurately through the geometrical positioning of the injection optical waveguide or the injection fibre. Since it is therefore desirable for the optical waveguides to be displaced relative to one another, the optical waveguides cannot be adhesively bonded to one another.

SUMMARY OF THE INVENTION

[0003] In the optical coupling device cited in the introduction, a first holding block is fixed to the chip and the optical fibre is held on the variable-length element. In this case, the variable-length element can oscillate or bend, which causes temporary or permanent deadadjustment of the fibre.

[0004] The invention is therefore [based on the object of] directed to ensuring improved guidance of the variable-length element parallel to its main extension direction and, in the process, to avoid additional effort. This [object] is achieved by an optical coupling device having the features specified in Patent Claim 1.

[0005] Since the guide [device] element has a second holding block as an abutment on which the variable-length element is guided parallel to its main extension direction, improved guidance of the variable-length element parallel to the coupling face is ensured in a simple way, and additional effort is avoided.

[0006] By means of this arrangement, varying the length of the variable-length element is made possible, but the movement of the element in the abutment is restricted only in the dimension perpendicular to the expansion direction of the variable-length element. At the same time, the guidance of the moveable axis is very accurate, so that any movements in the direction of the fixed axis are smaller than 1 micrometer. This means that the movement of the first optical waveguide (fibre) relative to the second optical waveguide (strip conductor) present on the optical component (chip or planar waveguide) takes place very exactly parallel to the surface of the component, and that deadadjustment in other spatial directions virtually does not occur.

[0007] A further advantageous configuration of the coupling device according to the invention is [characterized in] that the guide [device] element has a ferrule which is connected to the variable-length element and is mounted in a hole in the second holding block such that it can be displaced in the direction of the axis of the variable-length element in which the variation in length takes place. At the same time, it is advantageous if the ferrule is guided in a suitable, commercially available coupling sleeve in the second holding block, which serves as an abutment.

[0008] A further advantageous configuration of the coupling device according to the invention is [characterized in] that the guide [device] element has a ferrule that is connected to the second holding block and is mounted in a hole in the variable-length element such that it can be displaced in the direction of the axis of the variable-length element in which the variation in length takes place. At the same time, it is advantageous if the ferrule is guided in the variable-length element via a sleeve.

[0009] In particular as the result of using a ferrule, for example a commercially available optical waveguide plug ferrule, which is fitted in the longitudinal direction of the variable-length element, particularly accurate guidance can be achieved.

[0010] A further advantageous configuration of the coupling device according to the invention is [characterized in] that the guide [device] element is formed by a tongue-and-groove connection between the variable-length element and the second holding block. A guide [device] element which is mechanically simply implemented is therefore provided, without having to make recourse to additional components.

[0011] A further advantageous configuration of the coupling device according to the invention is [characterized in] that the second holding block has a U-shaped cross section, and in that the variable-length element is guided in the U-shaped cross section of the second holding block. In this case, the result, on both sides of the variable-length element, is guide faces which ensure appropriately exact guidance. This provides an optical coupling device in which the optical connection between an optical fibre and an optical chip is achieved with high security and stability with cost-effective mounting.

[0012] A further advantageous configuration of the coupling device according to the invention is [characterized in] that an abutment is fixed to the variable-length element and acts in a displaceable manner on the second optical waveguide, the abutment advantageously having, on one side, a spring between one end of the abutment and the second optical waveguide and, on the other side, a setting screw between another end of the abutment and the second optical waveguide. The abutment fitted to the variable-length element is able to slide along the second optical waveguide. By means of the screw, the pressure and the position perpendicular to the surface of the second optical waveguide can be adjusted.

[0013] In coupling devices of the aforementioned type, hitherto the fibres have been adhesively bonded into V-grooves, and the cavities produced in the process have been filled with adhesive. Since the adhesive exhibits a different behaviour with respect to temperature, expansion coefficient, water absorption and the like from the fibres and holding blocks and, respectively, the variable-length element, stresses in the adhesive and therefore deadadjustment of the fibre can occur under changing ambient conditions. This may be avoided by the fibre being anchored, in particular adhesively bonded, in a ferrule arranged in a hole in the variable-length element.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] Exemplary embodiments of the invention will be explained in more detail below using the drawings, in which:

[0015] Figs. 1A and 1B show a side view and an end view, respectively, of a coupling device according to one exemplary embodiment of the invention;

[0016] Figs. 2A and 2B show a side view and, respectively, an end view of a further exemplary embodiment of the coupling device according to the invention;

[0017] Figs. 3A and 3B show a side view and, respectively, an end view of a further exemplary embodiment of the coupling device according to the invention;

[0018] Figs. 4A and 4B show a side view and, respectively, an end view of a further exemplary embodiment of the coupling device according to the invention;

[0019] Fig. 5 shows the schematic construction of the connection between the variable-length element and an optical fibre;

[0020] Fig. 6 shows a side view of the device according to Fig. 1; and

[0021] Fig. 7 shows an optical fibre array to be coupled to optical chips, with many parallel optical waveguides.

DETAILED DESCRIPTION OF THE INVENTION

[0022] Fig. 1A shows, as a first optical waveguide, a fibre 2 which is fixed via a ferrule 4 in a variable-length element 6. The element 6, produced from aluminium, for example, is fixed, in particular adhesively bonded, to a holding block 8 (glass or glass ceramic), which, in turn, is fixed or adhesively bonded to a second optical waveguide 10, an optical waveguide chip (also known as a planar waveguide) in this example.

[0023] Arranged at the free end 12 of the variable-length element 6, in an appropriate hole 14, is a ferrule 16, which projects beyond the free end 12 of the variable-length element 6. The free end of the ferrule 16 is mounted via a guide sleeve 18 in a second holding block 20, so that the variable-length element 6 can extend in the direction of its longitudinal axis but, on the other hand, cannot give way in the spatial directions orthogonal thereto. Since the ferrule 16 and the sleeve 18 are tried and tested standard components, secure guidance of the variable-length element 6 in the longitudinal axis of the same is ensured. Alternatively, the ferrule 16 can be fixed firmly in the holding block 20 and mounted such that it can slide in the variable-length element 6.

[0024] Fig. 2A shows, as a first optical waveguide, a fibre 22, which is fixed via a ferrule 24 in a variable-length element 26. The variable-length element 26 is fixed or adhesively bonded to a holding block 28, which in turn is fixed or adhesively bonded to a second optical waveguide 30, an optical waveguide chip in this example.

[0025] Provided in one end 32 of the variable-length element 26 is a groove 34, which acts on a corresponding tongue 36 on a second holding block 38 and in this way forms a tongue-and-groove connection between the variable-length element 26 and the second holding block 38.

[0026] In Fig. 3A, a fibre 42 is illustrated as the first optical waveguide being fixed via a ferrule 44 in a variable-length element 46. The variable-length element 46 is fixed or adhesively bonded to a holding block 48 which, in turn, is fixed or adhesively bonded to a second optical waveguide 50, an optical waveguide chip in this example.

[0027] At its free end 52, the variable-length element 46 is mounted on a holding block 54 with a U-shaped cross section, the variable-length element 46 being guided in the U-shaped cross section of the holding block 54. With its two legs 56, 58, the holding block 54 therefore engages around the front end 52 of the variable-length element 46, so that the latter is likewise satisfactorily guided.

[0028] In 4A, a fibre 62 is shown as the first optical waveguide, being fixed via a ferrule 64 in a variable-length element 66. The variable-length element 66 is fixed or adhesively bonded to a holding block 68 which, in turn, is fixed or adhesively bonded to a second optical waveguide 70, an optical waveguide chip in this example.

[0029] Fixed to the end of the variable-length element is an abutment 72 which engages in a displaceable manner on the second optical waveguide 70. As can be seen from Fig. 4B, the abutment 72 has a U-shaped cross section and is supported with one leg 74, via a spring 76, on one side of the second optical waveguide 70 and, on the other side, via a setting screw 80 arranged on the other leg 78 of the abutment 72, on the second optical waveguide. By means of the setting screw 80, the pressure and therefore the position of the variable-length element 66 can be adjusted.

[0030] A rectangular, elongate, variable-length element 82 is illustrated in end view in Fig. 5 and in side view in Fig. 6. The variable-length element 82 is fixed to a holding block 84, which is adhesively bonded onto the surface of an optical chip (not shown). The element 82 is connected to the holding block 84, likewise at one end.

[0031] A commercially available ferrule 86 is fixed into the element 82, in an appropriate hole 88. Fixed in the ferrule 88 is an optical fibre 90. The ferrule 88 can either be installed vertically into the element 82 or at an angle, in order to reduce reflections at the end face of the fibres. The ferrule can also be a multiple fibre ferrule.

[0032] Fig. 7 shows a group of fibres in a block 92, the fibres 90 in each case being arranged in a ferrule 86, which are in turn inserted or adhesively bonded into corresponding holes 88 in the block 92.

WILEY-INTERSCIENCE

Patent claims

1. [Optical] An optical coupling device for cross-coupling light from a first optical waveguide [(2)] into a second optical waveguide [(10)], it being possible for the relative position of the two optical waveguide end faces in relation to each other to be influenced with the aid of a variable-length element [(6, 26, 46, 66, 86)] which holds the first optical waveguide [(2)] and the variable-length element [(6, 26, 46, 66, 86)] being fixed via a first holding element [(8, 28, 48)] to a structure containing the second optical waveguide [(10)] and having a guide [device (18, 20)] element which permits the variable-length element [(6, 26, 46, 66, 86)] to lengthen only in a spatial direction oriented substantially parallel to the longitudinal axis of the element.
2. [Optical] An optical coupling device, [characterized in that] wherein the guide [device] element has a second holding block [(20, 38, 54, 72)] as an abutment, on which the variable-length element [(6, 26, 46, 66, 86)] is guided parallel to its extension direction.
3. [Device] The device according to Claim 1, [characterized in that] wherein the guide [device] element has a ferrule [(16)] which is connected to the variable-length element [(6)] and is mounted in a hole in the second holding block [(20)] such that it can be displaced in the direction of the axis of the variable-length element in which the variation in length takes place.
4. [Device] The device according to Claim 2, [characterized in that] wherein the ferrule [(16)] is guided in the second holding block via a sleeve [(18)].
5. [Device] The device according to Claim 1, [characterized in that] wherein the guide [device] element has a ferrule which is connected to the second holding block and is mounted in a hole in the variable-length element such that it can be displaced in the direction of the axis of the variable-length element in which the variation in length takes place.
6. [Device] The device according to Claim 4, [characterized in that] wherein the ferrule is guided in the variable-length element via a sleeve.
7. [Device] The device according to Claim 1, [characterized in that] wherein the guide [device] element is formed by a groove-[(34)]-and-tongue-[(36)] connection between the variable-length element [(26)] and the second holding block [(38)].

8. [Device] The device according to Claim 1, [characterized in that] wherein the second holding block [(54)] has a U-shaped cross section, and in that the variable-length element [(46)] is guided in the U-shaped cross section of the second holding block [(54)].
9. [Device] The device according to Claim 1, [characterized in that] wherein an abutment [(72)], which acts in a displaceable manner on the second optical waveguide [(70)], is fixed to the variable-length element [(66)].
10. [Device] The device according to Claim 6, [characterized in that] wherein the abutment has, on one side, a spring [(76)] between one end of the abutment [(72)] and the second optical waveguide [(70)] and, on the other side, a setting screw [(80)] between another end of the abutment [(72)] and the second optical waveguide [(70)].

Abstract of the Invention

[Optical coupling device]

The optical coupling device of the invention serves to cross-couple light from a first into a second optical waveguide [(2, 10)], a variable-length element [(6)] influencing the relative position of the opposite end faces of the two optical waveguides [(2, 10)] in relation to one another. The element [(26)] fixing one of the two optical waveguides [(2)] is fixed by a first holding element [(8)] to a unit containing the other optical waveguide [(10)]. It has a guide [device] element [(14, 16)] which engages in a second holding element [(18, 20)] and permits the element [(6)] to lengthen substantially only in a spatial direction oriented parallel to the longitudinal axis of the element.

[Figure 1]

Figure 1

CLEAN VERSION OF AMENDED APPLICATION

SI01-011

OPTICAL COUPLING DEVICE**CROSS-REFERENCE TO RELATED APPLICATIONS**

[0001] This application claims the benefit of priority under 35 U.S.C. § 119 of German Patent Application No. 19934178.8, filed July 21, 1999, and is a national stage filing under 35 U.S.C. § 371 of PCT Application No. PCT/DE00/02397, filed July 21, 2000.

FIELD OF THE INVENTION

[0002] The invention relates to an optical coupling device for cross-coupling light from a first optical waveguide into a second optical waveguide. Such a coupling device is known, for example, from WO 98/13718.

BACKGROUND OF THE INVENTION

[0003] Coupling devices are used in optical filters according to the phased-array principle with an injection face in which light enters at a specific geometrical position, the geometrical position influencing the output wavelength of the optical filter. Such optical filters according to the phased-array principle are used, in particular, as multiplexers or demultiplexers in optical wavelength multiplex operation (WDM), since they exhibit low insertion attenuation and high cross-talk suppression. The optical filter has, as its essential component, a plurality of curved optical waveguides of different length, which form a phase-shifter region. German Patent Application DE 44 22 651.9 describes that the central wavelength of a phased-array filter can be established through the position of an injection optical waveguide, which guides the light into the layered optical waveguide. In this way, the central wavelength of the optical filter can be adjusted accurately through the geometrical positioning of the injection optical waveguide or the injection fibre. Since it is therefore desirable for the optical waveguides to be displaced relative to one another, the optical waveguides cannot be adhesively bonded to one another.

SUMMARY OF THE INVENTION

[0004] In the optical coupling device cited in the introduction, a first holding block is fixed to the chip and the optical fibre is held on the variable-length element. In this case, the variable-length element can oscillate or bend, which causes temporary or permanent deadadjustment of the fibre.

[0005] The invention is therefore directed to ensuring improved guidance of the variable-length element parallel to its main extension direction and, in the process, to avoid additional effort. This is achieved by an optical coupling device having the features specified in Patent Claim 1.

[0006] Since the guide element has a second holding block as an abutment on which the variable-length element is guided parallel to its main extension direction, improved guidance of the variable-length element parallel to the coupling face is ensured in a simple way, and additional effort is avoided.

[0007] By means of this arrangement, varying the length of the variable-length element is made possible, but the movement of the element in the abutment is restricted only in the dimension perpendicular to the expansion direction of the variable-length element. At the same time, the guidance of the moveable axis is very accurate, so that any movements in the direction of the fixed axis are smaller than 1 micrometer. This means that the movement of the first optical waveguide (fibre) relative to the second optical waveguide (strip conductor) present on the optical component (chip or planar waveguide) takes place very exactly parallel to the surface of the component, and that deadadjustment in other spatial directions virtually does not occur.

[0008] A further advantageous configuration of the coupling device according to the invention is that the guide element has a ferrule which is connected to the variable-length element and is mounted in a hole in the second holding block such that it can be displaced in the direction of the axis of the variable-length element in which the variation in length takes place. At the same time, it is advantageous if the ferrule is guided in a suitable, commercially available coupling sleeve in the second holding block, which serves as an abutment.

[0009] A further advantageous configuration of the coupling device according to the invention is that the guide element has a ferrule that is connected to the second holding block and is mounted in a hole in the variable-length element such that it can be displaced in the direction of the axis of the variable-length element in which the variation in length takes place. At the same time, it is advantageous if the ferrule is guided in the variable-length element via a sleeve.

[0010] In particular as the result of using a ferrule, for example a commercially available optical waveguide plug ferrule, which is fitted in the longitudinal direction of the variable-length element, particularly accurate guidance can be achieved.

[0011] A further advantageous configuration of the coupling device according to the invention is that the guide element is formed by a tongue-and-groove connection between the variable-length element and the second holding block. A guide element which is mechanically simply implemented is therefore provided, without having to make recourse to additional components.

[0012] A further advantageous configuration of the coupling device according to the invention is that the second holding block has a U-shaped cross section, and in that the variable-length element is guided in the U-shaped cross section of the second holding block. In this case, the result, on both sides of the variable-length element, is guide faces which ensure appropriately exact guidance. This provides an optical coupling device in which the optical connection between an optical fibre and an optical chip is achieved with high security and stability with cost-effective mounting.

[0013] A further advantageous configuration of the coupling device according to the invention is that an abutment is fixed to the variable-length element and acts in a displaceable manner on the second optical waveguide, the abutment advantageously having, on one side, a spring between one end of the abutment and the second optical waveguide and, on the other side, a setting screw between another end of the abutment and the second optical waveguide. The abutment fitted to the variable-length element is able to slide along the second optical waveguide. By means of the screw, the pressure and the position perpendicular to the surface of the second optical waveguide can be adjusted.

[0014] In coupling devices of the aforementioned type, hitherto the fibres have been adhesively bonded into V-grooves, and the cavities produced in the process have been filled with adhesive. Since the adhesive exhibits a different behaviour with respect to temperature, expansion coefficient, water absorption and the like from the fibres and holding blocks and, respectively, the variable-length element, stresses in the adhesive and therefore deadadjustment of the fibre can occur under changing ambient conditions. This may be avoided by the fibre being anchored, in particular adhesively bonded, in a ferrule arranged in a hole in the variable-length element.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] Exemplary embodiments of the invention will be explained in more detail below using the drawings, in which:

[0016] Figs. 1A and 1B show a side view and an end view, respectively, of a coupling device according to one exemplary embodiment of the invention;

[0017] Figs. 2A and 2B show a side view and, respectively, an end view of a further exemplary embodiment of the coupling device according to the invention;

[0018] Figs. 3A and 3B show a side view and, respectively, an end view of a further exemplary embodiment of the coupling device according to the invention;

[0019] Figs. 4A and 4B show a side view and, respectively, an end view of a further exemplary embodiment of the coupling device according to the invention;

[0020] Fig. 5 shows the schematic construction of the connection between the variable-length element and an optical fibre;

[0021] Fig. 6 shows a side view of the device according to Fig. 1; and

[0022] Fig. 7 shows an optical fibre array to be coupled to optical chips, with many parallel optical waveguides.

DETAILED DESCRIPTION OF THE INVENTION

[0023] Fig. 1A shows, as a first optical waveguide, a fibre 2 which is fixed via a ferrule 4 in a variable-length element 6. The element 6, produced from aluminium, for example, is fixed, in particular adhesively bonded, to a holding block 8 (glass or glass ceramic), which, in turn, is fixed or adhesively bonded to a second optical waveguide 10, an optical waveguide chip (also known as a planar waveguide) in this example.

[0024] Arranged at the free end 12 of the variable-length element 6, in an appropriate hole 14, is a ferrule 16, which projects beyond the free end 12 of the variable-length element 6. The free end of the ferrule 16 is mounted via a guide sleeve 18 in a second holding block 20, so that the variable-length element 6 can extend in the direction of its longitudinal axis but, on the other hand, cannot give way in the spatial directions orthogonal thereto. Since the ferrule 16 and the sleeve 18 are tried and tested standard components, secure guidance of the variable-length element 6 in the longitudinal axis of the same is ensured. Alternatively, the ferrule 16 can be fixed firmly in the holding block 20 and mounted such that it can slide in the variable-length element 6.

[0025] Fig. 2A shows, as a first optical waveguide, a fibre 22, which is fixed via a ferrule 24 in a variable-length element 26. The variable-length element 26 is fixed or adhesively bonded to a holding block 28, which in turn is fixed or adhesively bonded to a second optical waveguide 30, an optical waveguide chip in this example.

[0026] Provided in one end 32 of the variable-length element 26 is a groove 34, which acts on a corresponding tongue 36 on a second holding block 38 and in this way forms a tongue-and-groove connection between the variable-length element 26 and the second holding block 38.

[0027] In Fig. 3A, a fibre 42 is illustrated as the first optical waveguide being fixed via a ferrule 44 in a variable-length element 46. The variable-length element 46 is fixed or adhesively bonded to a holding block 48 which, in turn, is fixed or adhesively bonded to a second optical waveguide 50, an optical waveguide chip in this example.

[0028] At its free end 52, the variable-length element 46 is mounted on a holding block 54 with a U-shaped cross section, the variable-length element 46 being guided in the U-shaped cross section of the holding block 54. With its two legs 56, 58, the holding block 54 therefore engages around the front end 52 of the variable-length element 46, so that the latter is likewise satisfactorily guided.

[0029] In 4A, a fibre 62 is shown as the first optical waveguide, being fixed via a ferrule 64 in a variable-length element 66. The variable-length element 66 is fixed or adhesively bonded to a holding block 68 which, in turn, is fixed or adhesively bonded to a second optical waveguide 70, an optical waveguide chip in this example.

[0030] Fixed to the end of the variable-length element is an abutment 72 which engages in a displaceable manner on the second optical waveguide 70. As can be seen from Fig. 4B, the abutment 72 has a U-shaped cross section and is supported with one leg 74, via a spring 76, on one side of the second optical waveguide 70 and, on the other side, via a setting screw 80 arranged on the other leg 78 of the abutment 72, on the second optical waveguide. By means of the setting screw 80, the pressure and therefore the position of the variable-length element 66 can be adjusted.

[0031] A rectangular, elongate, variable-length element 82 is illustrated in end view in Fig. 5 and in side view in Fig. 6. The variable-length element 82 is fixed to a holding block 84, which is adhesively bonded onto the surface of an optical chip (not shown). The element 82 is connected to the holding block 84, likewise at one end.

[0032] A commercially available ferrule 86 is fixed into the element 82, in an appropriate hole 88. Fixed in the ferrule 88 is an optical fibre 90. The ferrule 88 can either be installed vertically into the element 82 or at an angle, in order to reduce reflections at the end face of the fibres. The ferrule can also be a multiple fibre ferrule.

[0033] Fig. 7 shows a group of fibres in a block 92, the fibres 90 in each case being arranged in a ferrule 86, which are in turn inserted or adhesively bonded into corresponding holes 88 in the block 92.

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Patent claims

1. An optical coupling device for cross-coupling light from a first optical waveguide into a second optical waveguide, it being possible for the relative position of the two optical waveguide end faces in relation to each other to be influenced with the aid of a variable-length element which holds the first optical waveguide and the variable-length element being fixed via a first holding element to a structure containing the second optical waveguide and having a guide element which permits the variable-length element to lengthen only in a spatial direction oriented substantially parallel to the longitudinal axis of the element.
2. An optical coupling device, wherein the guide element has a second holding block as an abutment, on which the variable-length element is guided parallel to its extension direction.
3. The device according to Claim 1, wherein the guide element has a ferrule which is connected to the variable-length element and is mounted in a hole in the second holding block such that it can be displaced in the direction of the axis of the variable-length element in which the variation in length takes place.
4. The device according to Claim 2, wherein the ferrule is guided in the second holding block via a sleeve.
5. The device according to Claim 1, wherein the guide element has a ferrule which is connected to the second holding block and is mounted in a hole in the variable-length element such that it can be displaced in the direction of the axis of the variable-length element in which the variation in length takes place.
6. The device according to Claim 4, wherein the ferrule is guided in the variable-length element via a sleeve.
7. The device according to Claim 1, wherein the guide element is formed by a groove-and-tongue connection between the variable-length element and the second holding block.
8. The device according to Claim 1, wherein the second holding block has a U-shaped cross section, and in that the variable-length element is guided in the U-shaped cross section of the second holding block.

9. The device according to Claim 1, wherein an abutment, which acts in a displaceable manner on the second optical waveguide, is fixed to the variable-length element.
10. The device according to Claim 6, wherein the abutment has, on one side, a spring between one end of the abutment and the second optical waveguide and, on the other side, a setting screw between another end of the abutment and the second optical waveguide.

Abstract

The optical coupling device of the invention serves to cross-couple light from a first into a second optical waveguide, a variable-length element influencing the relative position of the opposite end faces of the two optical waveguides in relation to one another. The element fixing one of the two optical waveguides is fixed by a first holding element to a unit containing the other optical waveguide. It has a guide element which engages in a second holding element and permits the element to lengthen substantially only in a spatial direction oriented parallel to the longitudinal axis of the element.

Figure 1

Figure 1

3/pst

Original Translation

Description

Optical coupling device

- 5 The invention relates to an optical coupling device for cross-coupling light from a first optical waveguide into a second optical waveguide. Such a coupling device is known, for example, from WO 98/13718.
- 10 Such coupling devices are used in optical filters according to the phased-array principle with an injection face in which light enters at a specific geometrical position, the geometrical position influencing the output wavelength of the optical
- 15 filter. Such optical filters according to the phased-array principle are used, in particular, as multiplexers or demultiplexers in optical wavelength multiplex operation (WDM), since they exhibit low insertion attenuation and high cross-talk suppression.
- 20 The optical filter has, as its essential component, a plurality of curved optical waveguides of different length, which form a phase-shifter region. German Patent Application DE 44 22 651.9 describes that the central wavelength of a phased-array filter can be
- 25 established through the position of an injection optical waveguide, which guides the light into the layered optical waveguide. In this way, the central wavelength of the optical filter can be adjusted accurately through the geometrical positioning of the
- 30 injection optical waveguide or the injection fibre. Since it is therefore desirable for the optical waveguides to be displaced relative to one another, the optical waveguides cannot be adhesively bonded to one another.
- 35 In the optical coupling device cited in the introduction, a first holding block is fixed to the chip and the optical fibre is held on the variable-length element. In this case, the variable-length

[illegible]

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By means of this arrangement, varying the length of the variable-length element is made possible, but the movement of the element in the abutment is restricted only in the dimension perpendicular to the expansion direction of the variable-length element. At the same time, the guidance of the moveable axis is very accurate, so that any movements in the direction of the fixed axis are smaller than 1 micrometer. This means that the movement of the first optical waveguide (fibre) relative to the second optical waveguide (strip conductor) present on the optical component (chip) takes place very exactly parallel to the surface of the component, and that deadadjustment in other spatial directions virtually does not occur.

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At the same time, it is advantageous if the ferrule is guided in a suitable, commercially available coupling sleeve in the second holding block, which serves as an abutment.

5

A further advantageous configuration of the device according to the invention is characterized in that the guide device has a ferrule that is connected to the second holding block and is mounted in a hole in the variable-length element such that it can be displaced
10 in the direction of the axis of the variable-length element in which the variation in length takes place. At the same time, it is advantageous if the ferrule is guided in the variable-length element via a sleeve.

15

In particular as the result of using a ferrule, for example a commercially available optical waveguide plug ferrule, which is fitted in the longitudinal direction of the variable-length element, particularly accurate
20 guidance can be achieved.

A further advantageous configuration of the device according to the invention is characterized in that the guide device is formed by a tongue-and-groove
25 connection between the variable-length element and the second holding block. A guide device which is mechanically simply implemented is therefore provided, without having to make recourse to additional components.

30

A further advantageous configuration of the device according to the invention is characterized in that the second holding block has a U-shaped cross section, and in that the variable-length element is guided in the U-
35 shaped cross section of the second holding block. In this case, the result, on both sides of the variable-length element, is guide faces which ensure appropriately exact guidance. This provides an optical coupling device in which the optical connection between

an optical fibre and an optical chip is achieved with high security and stability with cost-effective mounting.

5 A further advantageous configuration of the device according to the invention is characterized in that an abutment is fixed to the variable-length element and acts in a displaceable manner on the second optical waveguide, the abutment advantageously having, on one
10 side, a spring between one end of the abutment and the second optical waveguide and, on the other side, a setting screw between another end of the abutment and the second optical waveguide. The abutment fitted to the variable-length element is able to slide along the
15 second optical waveguide. By means of the screw, the pressure and the position perpendicular to the surface of the second optical waveguide can be adjusted.

In coupling devices of the aforementioned type,
20 hitherto the fibres have been adhesively bonded into V-grooves, and the cavities produced in the process have been filled with adhesive. Since the adhesive exhibits a different behaviour with respect to temperature, expansion coefficient, water absorption and the like
25 from the fibres and holding blocks and, respectively, the variable-length element, stresses in the adhesive and therefore deadadjustment of the fibre can occur under changing ambient conditions. This may be avoided by the fibre being anchored, in particular adhesively bonded,
30 in a ferrule arranged in a hole in the variable-length element.

Exemplary embodiments of the invention will be explained in more detail below using the drawings, in
35 which:

Figs. 1A and 1B show a side view and an end view, respectively, of a coupling device according to one exemplary embodiment of the invention;

Figs. 2A and 2B show a side view and, respectively, an end view of a further exemplary embodiment of the coupling device according to the invention;

5 Figs. 3A and 3B show a side view and, respectively, an end view of a further exemplary embodiment of the coupling device according to the invention;

10 Figs. 4A and 4B show a side view and, respectively, an end view of a further exemplary embodiment of the coupling device according to the invention;

15 Fig. 5 shows the schematic construction of the connection between the variable-length element and an optical fibre;

Fig. 6 shows a side view of the device according to Fig. 1; and

20 Fig. 7 shows an optical fibre array to be coupled to optical chips, with many parallel optical waveguides.

25 Fig. 1A shows, as a first optical waveguide, a fibre 2 which is fixed via a ferrule 4 in a variable-length element 6. The element 6, produced from aluminium, for example, is fixed, in particular adhesively bonded, to a holding block 8 (glass or glass ceramic), which, in turn, is fixed or adhesively bonded to a second optical
30 waveguide 10, an optical waveguide chip in this example.

35 Arranged at the free end 12 of the variable-length element 6, in an appropriate hole 14, is a ferrule 16, which projects beyond the free end 12 of the variable-length element 6. The free end of the ferrule 16 is mounted via a guide sleeve 18 in a second holding block 20, so that the variable-length element 6 can extend in the direction of its longitudinal axis but, on the

other hand, cannot give way in the spatial directions orthogonal thereto. Since the ferrule 16 and the sleeve 18 are tried and tested standard components, secure guidance of the variable-length element 6 in the longitudinal axis of the same is ensured. Alternatively, the ferrule 16 can be fixed firmly in the holding block 20 and mounted such that it can slide in the variable-length element 6.

Fig. 2A shows, as a first optical waveguide, a fibre 22, which is fixed via a ferrule 24 in a variable-length element 26. The variable-length element 26 is fixed or adhesively bonded to a holding block 28, which in turn is fixed or adhesively bonded to a second optical waveguide 30, an optical waveguide chip in this example.

Provided in one end 32 of the variable-length element 26 is a groove 34, which acts on a corresponding tongue 36 on a second holding block 38 and in this way forms a tongue-and-groove connection between the variable-length element 26 and the second holding block 38.

In Fig. 3A, a fibre 42 is illustrated as the first optical waveguide being fixed via a ferrule 44 in a variable-length element 46. The variable-length element 46 is fixed or adhesively bonded to a holding block 48 which, in turn, is fixed or adhesively bonded to a second optical waveguide 50, an optical waveguide chip in this example.

At its free end 52, the variable-length element 46 is mounted on a holding block 54 with a U-shaped cross section, the variable-length element 46 being guided in the U-shaped cross section of the holding block 54. With its two legs 56, 58, the holding block 54 therefore engages around the front end 52 of the variable-length element 46, so that the latter is likewise satisfactorily guided.

In 4A, a fibre 62 is shown as the first optical waveguide, being fixed via a ferrule 64 in a variable-length element 66. The variable-length element 66 is
5 fixed or adhesively bonded to a holding block 68 which, in turn, is fixed or adhesively bonded to a second optical waveguide 70, an optical waveguide chip in this example.

10 Fixed to the end of the variable-length element is an abutment 72 which engages in a displaceable manner on the second optical waveguide 70. As can be seen from Fig. 4B, the abutment 72 has a U-shaped cross section and is supported with one leg 74, via a spring 76, on
15 one side of the second optical waveguide 70 and, on the other side, via a setting screw 80 arranged on the other leg 78 of the abutment 72, on the second optical waveguide. By means of the setting screw 80, the pressure and therefore the position of the variable-
20 length element 66 can be adjusted.

A rectangular, elongate, variable-length element 82 is illustrated in end view in Fig. 5 and in side view in Fig. 6. The variable-length element 82 is fixed to a
25 holding block 84, which is adhesively bonded onto the surface of an optical chip (not shown). The element 82 is connected to the holding block 84, likewise at one end.

30 A commercially available ferrule 86 is fixed into the element 82, in an appropriate hole 88. Fixed in the ferrule 88 is an optical fibre 90. The ferrule 88 can either be installed vertically into the element 82 or at an angle, in order to reduce reflections at the end
35 face of the fibres. The ferrule can also be a multiple fibre ferrule.

Fig. 7 shows a group of fibres in a block 92, the fibres 90 in each case being arranged in a ferrule 86,

Original translation - 8 -

which are in turn inserted or adhesively bonded into corresponding holes 88 in the block 92.

Patent claims

1. Optical coupling device for cross-coupling light from a first optical waveguide (2) into a second optical waveguide (10), it being possible for the relative position of the two optical waveguide end faces in relation to each other to be influenced with the aid of a variable-length element (6, 26, 46, 66, 86) which holds the first optical waveguide (2) and the variable-length element (6, 26, 46, 66, 86) being fixed via a first holding element (8, 28, 48) to a structure containing the second optical waveguide (10) and having a guide device (18, 20) which permits the element (6, 26, 46, 66, 86) to lengthen only in a spatial direction oriented substantially parallel to the longitudinal axis of the element.
2. Optical coupling device, characterized in that the guide device has a second holding block (20, 38, 54, 72) as an abutment, on which the variable-length element (6, 26, 46, 66, 86) is guided parallel to its extension direction.
3. Device according to Claim 1, characterized in that the guide device has a ferrule (16) which is connected to the variable-length element (6) and is mounted in a hole in the second holding block (20) such that it can be displaced in the direction of the axis of the variable-length element in which the variation in length takes place.
4. Device according to Claim 2, characterized in that the ferrule (16) is guided in the second holding block via a sleeve (18).
5. Device according to Claim 1, characterized in that the guide device has a ferrule which is connected

to the second holding block and is mounted in a hole in the variable-length element such that it can be displaced in the direction of the axis of the variable-length element in which the variation in length takes place.

6. Device according to Claim 4, characterized in that the ferrule is guided in the variable-length element via a sleeve.

7. Device according to Claim 1, characterized in that the guide device is formed by a groove-(34)-and-tongue-(36) connection between the variable-length element (26) and the second holding block (38).

8. Device according to Claim 1, characterized in that the second holding block (54) has a U-shaped cross section, and in that the variable-length element (46) is guided in the U-shaped cross section of the second holding block (54).

9. Device according to Claim 1, characterized in that an abutment (72), which acts in a displaceable manner on the second optical waveguide (70), is fixed to the variable-length element (66).

10. Device according to Claim 6, characterized in that the abutment has, on one side, a spring (76) between one end of the abutment (72) and the second optical waveguide (70) and, on the other side, a setting screw (80) between another end of the abutment (72) and the second optical waveguide (70).

Original Translation

Abstract

1. Optical coupling device

5 2. The optical coupling device serves to cross-couple
light from a first into a second optical waveguide
(2, 10), a variable-length element (6) influencing
the relative position of the opposite end faces of
the two optical waveguides (2, 10) in relation to
10 one another. The element (26) fixing one of the
two optical waveguides (2) is fixed by a first
holding element (8) to a unit containing the other
optical waveguide (10). It has a guide device (14,
16) which engages in a second holding element (18,
15 20) and permits the element (6) to lengthen
substantially only in a spatial direction oriented
parallel to the longitudinal axis of the element.

3. Figure 1

FIG 1A

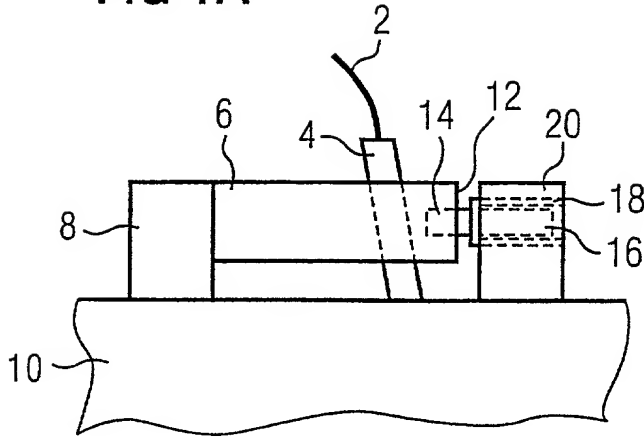


FIG 1B

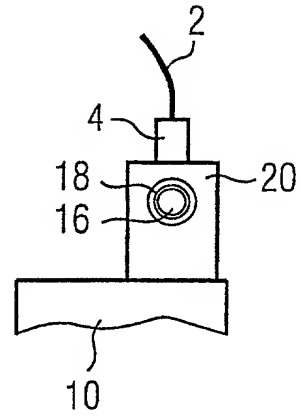


FIG 2A

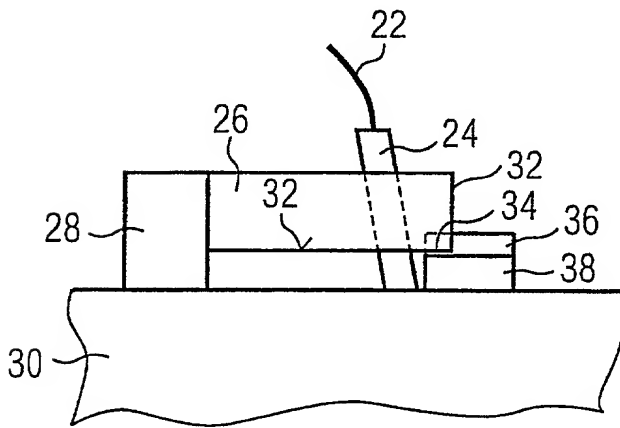


FIG 2B

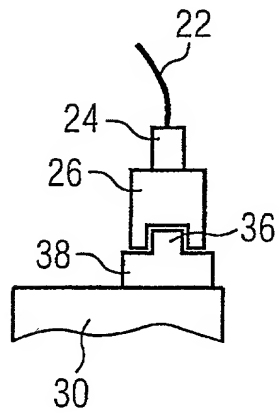


FIG 3A

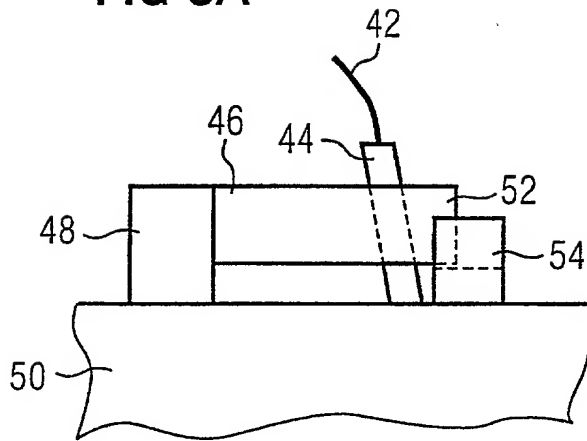


FIG 3B

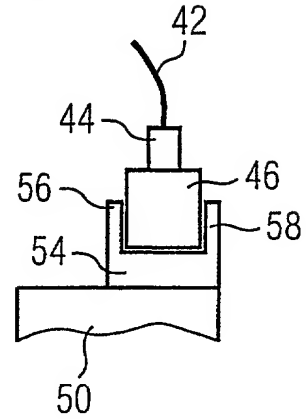


FIG 4A

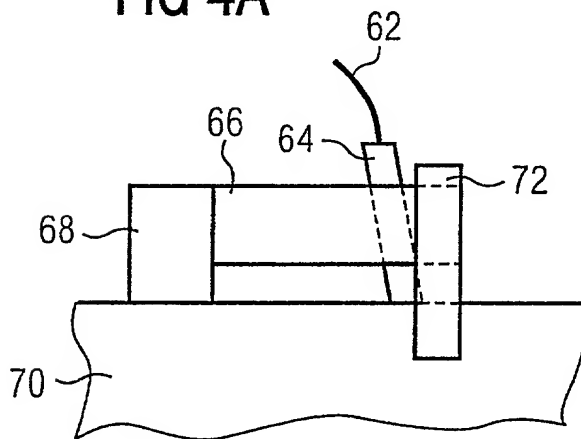
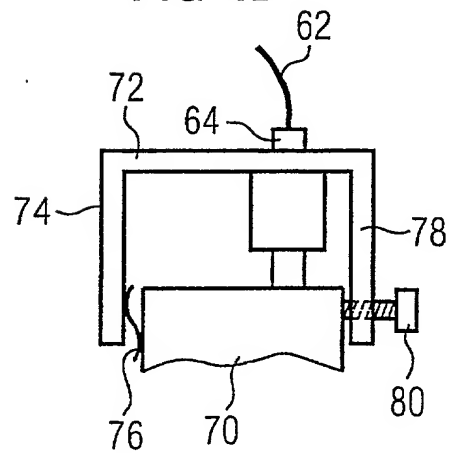


FIG 4B



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FIG 5

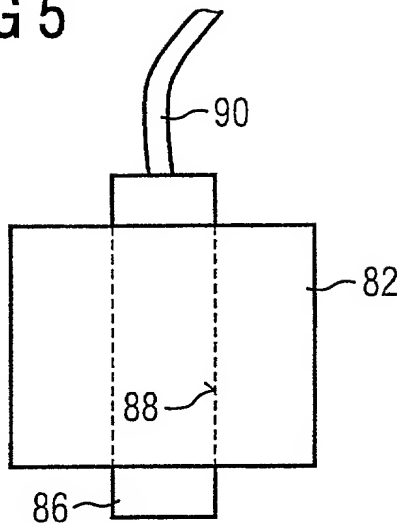


FIG 6

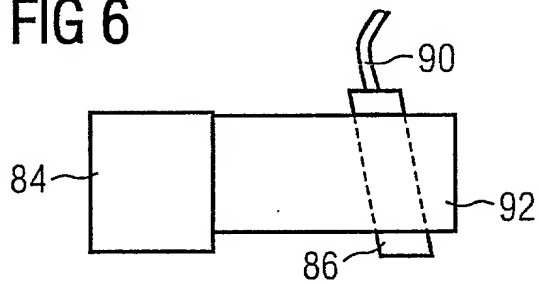
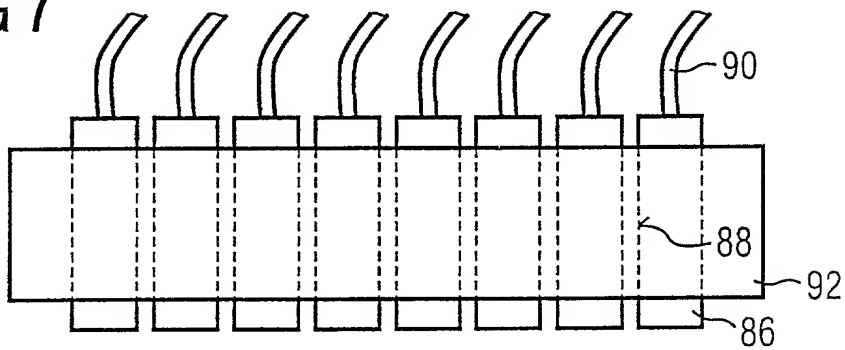


FIG 7



As a below named inventor, I declare that:

My residence, Post Office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **OPTICAL COUPLING DEVICE**.

The specification of which (check only one item below):

☐ is attached hereto

☒ was filed as United States Application Serial No. 10/031,917 on 1/19/02
and was amended on (if applicable)

☐ was filed as PCT international application number , on , and was
amended under PCT Article 19 on (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate or 365(a) of any PCT international application which designated at least one country other than the United States, listed below and have also identified below any foreign application for patent or inventor's certificate, on the same subject matter, having a filing date before that of the application on which priority is claimed:

☒ Country: Germany Application No.: 19934178.8 Filing Date: 7/21/99

☐ NONE

I hereby claim the benefit under Title 35 United States Code § 119(e) and § 120 of any United States application(s) or 365(c) of any PCT international application designating the United States listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35 United States Code § 112, I acknowledge the duty to disclose material information as defined in Title 37 Code of Federal Regulations, § 1.56 which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

☐ Provisional No.: Filed: Status:

☒ Application No.: Filed: Status:

PCT Application No: Filed: 7/21/00 Status: filed

PCT/DE00/02397

☐ NONE

DECLARATION IN ORIGINAL APPLICATION

U.S. Attorney Docket No.: SI01-011

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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